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UCRL-CONF-201683

Three-dimensional Global Model Approaches to Understanding Stratospheric Impacts on Tropospheric Ozone

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Bozeman, MT, United States
September 7, 2003 through September 12, 2003

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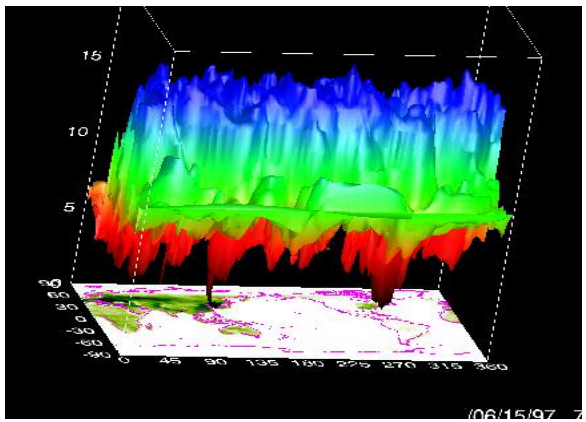

Cynthia Atherton

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Thanks to D. Bergmann, P. Cameron-Smith, P. Connell,J. Dignon, D. Rotman, and J. Tannahill, and colleagues at Argonne Natl Lab, PNNL

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Gordon Research Conference, 9/10/03

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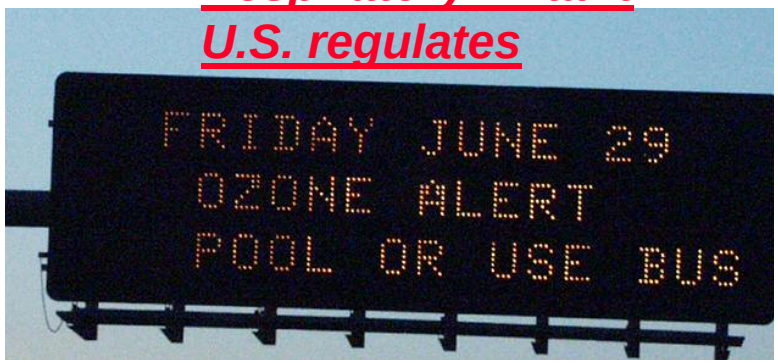
Why tropospheric ozone?

Respiratory irritant
U.S. regulates

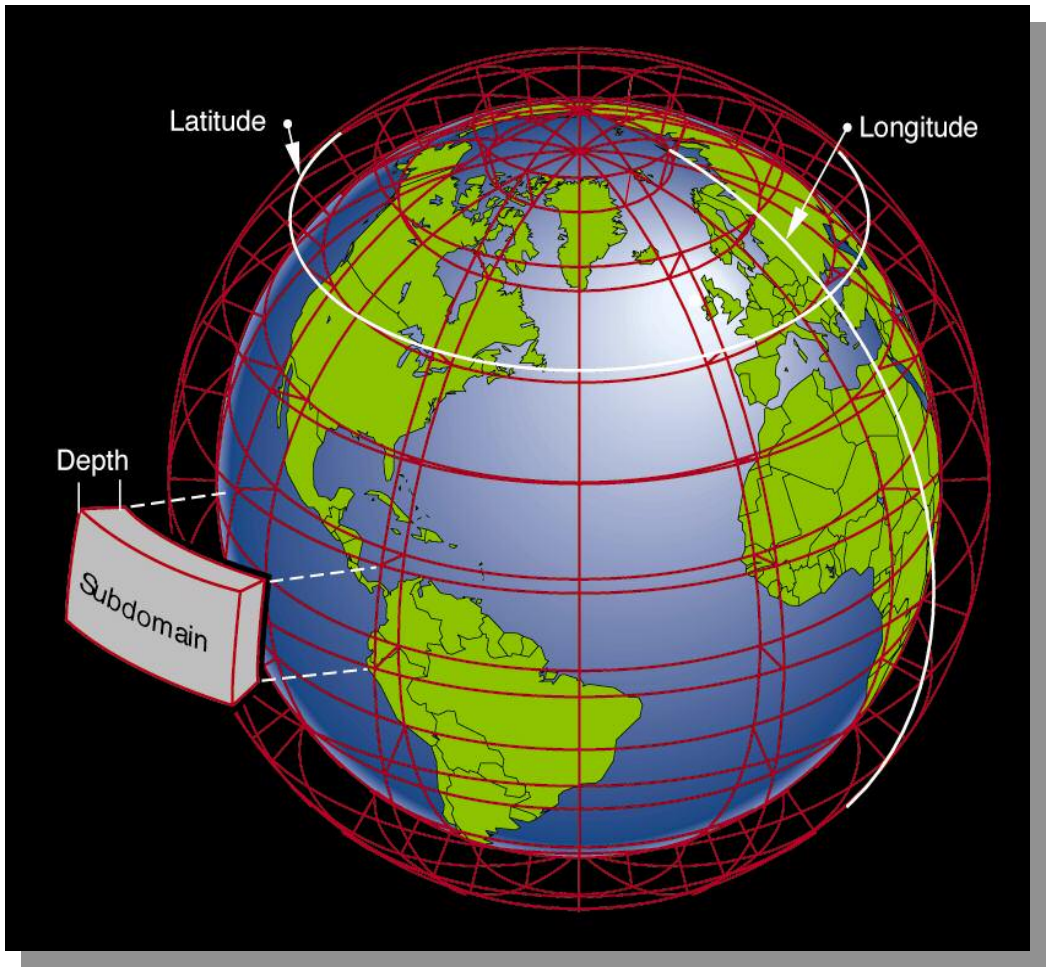


Damages materials

Damages plants

(NCS ARS)

This talk: Use IMPACT model (troposphere AND stratosphere) to study photochemistry & transport



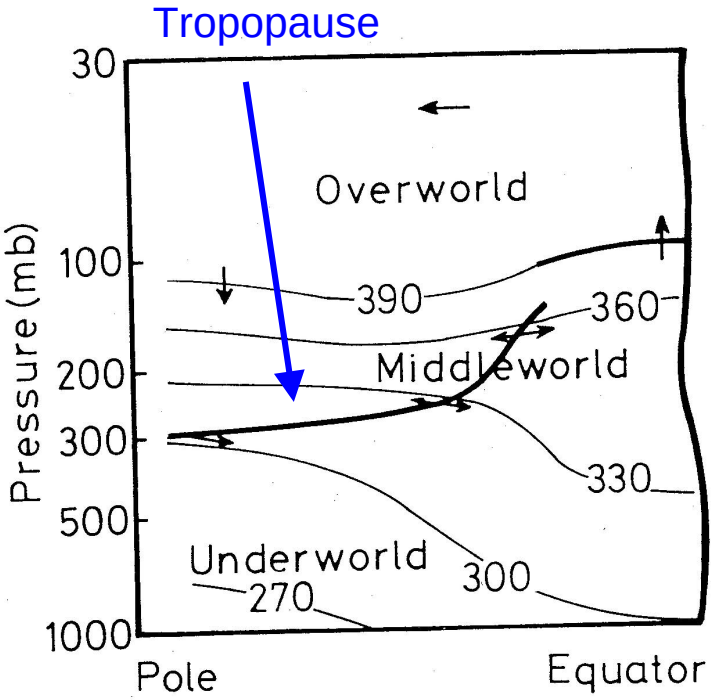
- **Processes:** Chemistry, photolysis, advection, diffusion, wet & dry deposition
- **Species:** CO, CH_4, NO, NO_2, OH, O_3, C_5H_8, NMHCs, PAN, HNO_3, C_xH_y, BrO, ClO, (etc…to > 200)
- **Meteorology:**

  MACCM3

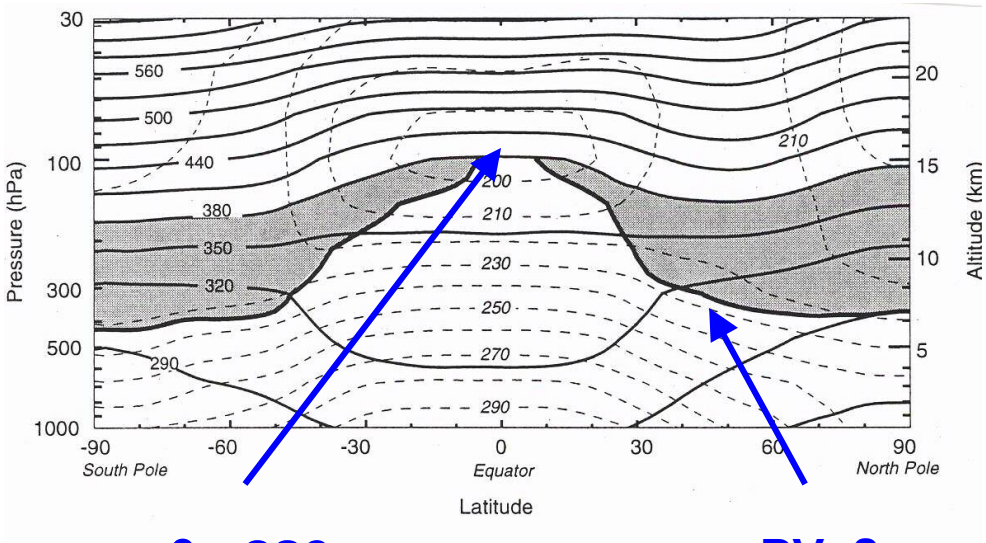
  NASA/DAO (assimilated)
- **Resolution:**

  Met. Driven
  (2° x 2.5° here)

Many views of “troposphere” (T, PV, θ, O_3, …)

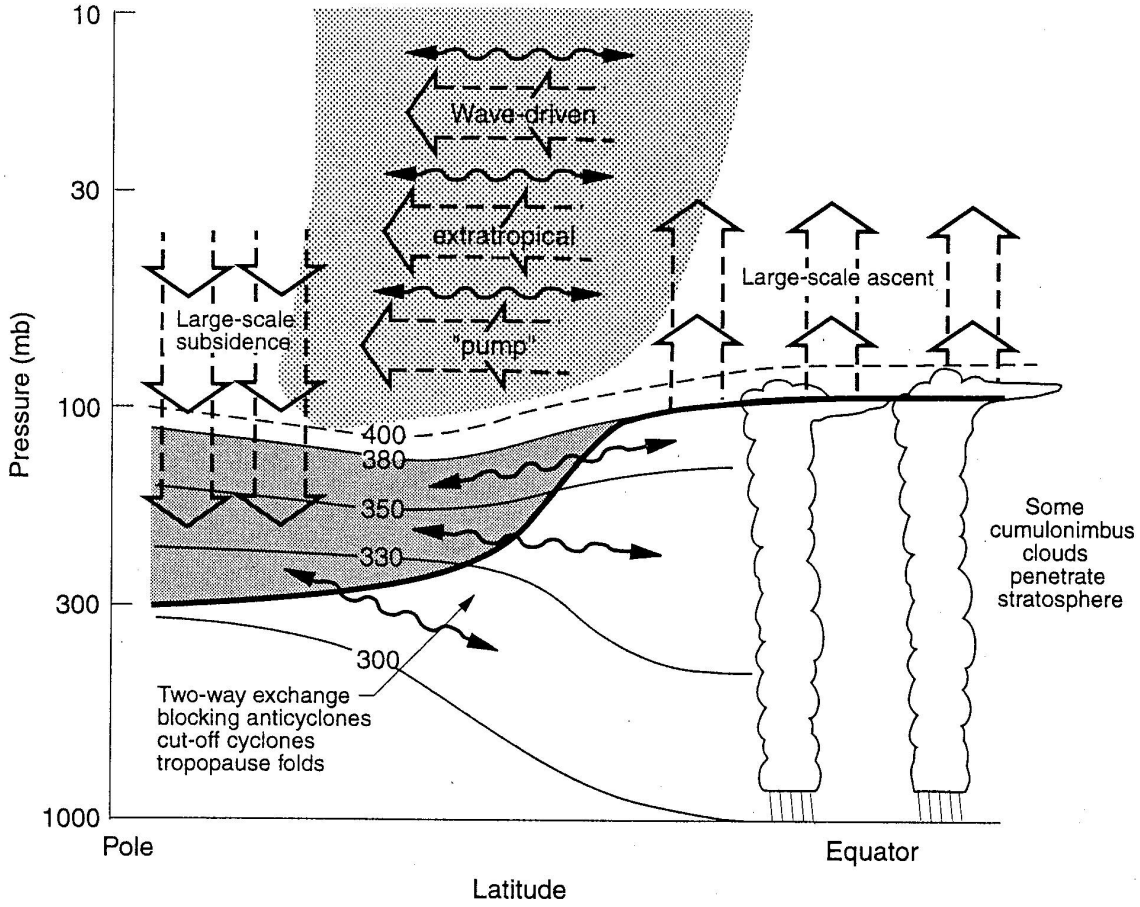


Hoskins, 1991



Holton et al., 1995

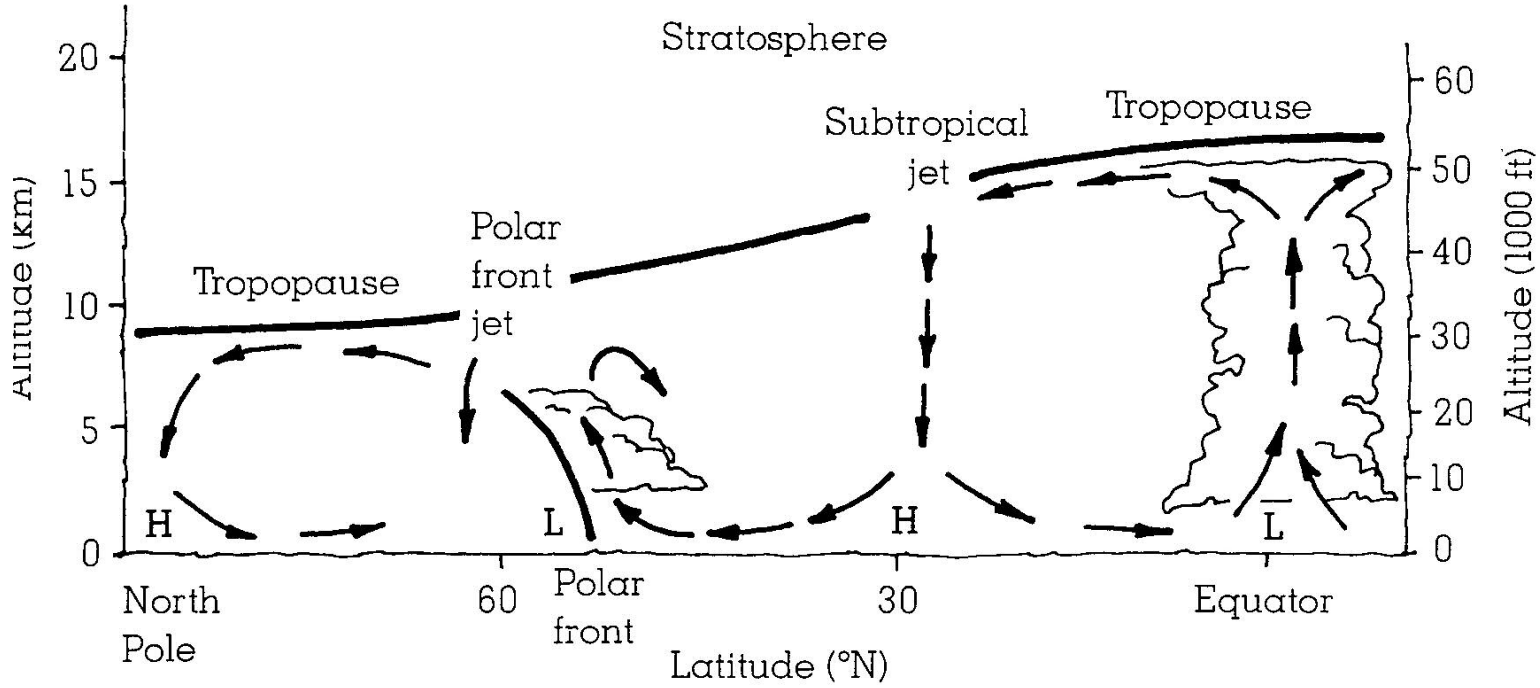
In-situ photochemistry, advection within troposphere and stratospheric transport important globally for O_3



Holton et al., 1995

- Cyclogenesis
- Cutoff cyclones
- Blocking anticyclones
- Baroclinic tropopause folding
- Gravity waves,
- <streamers>

We might expect strong transport near tropopause jets

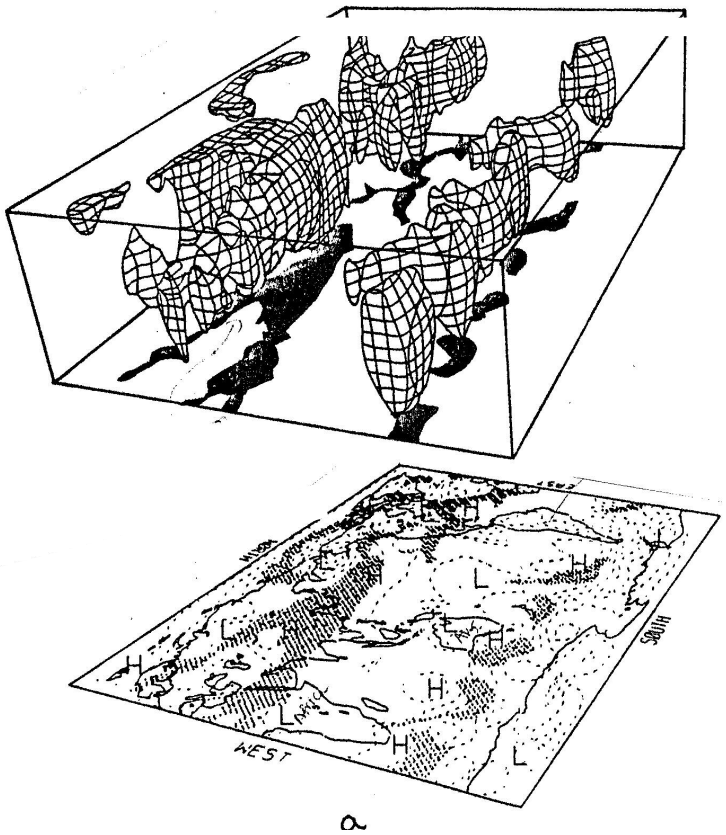


Cyclogenesis, cutoff cyclones, tropopause folding, blocking anticyclones, …

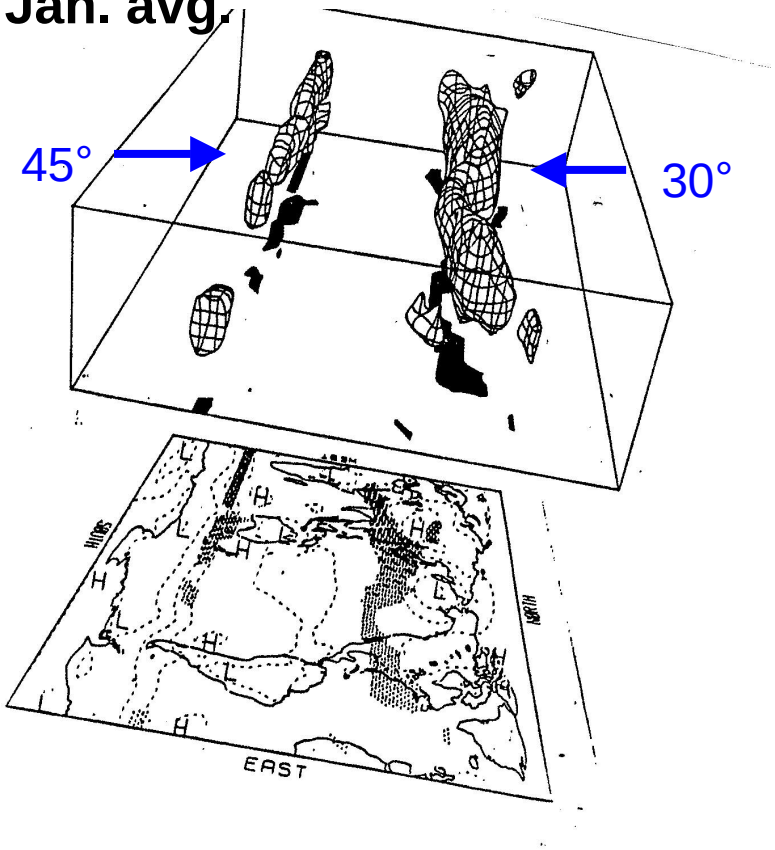
(Aherns, 1982)

There are differences between instantaneous and time averaged jets

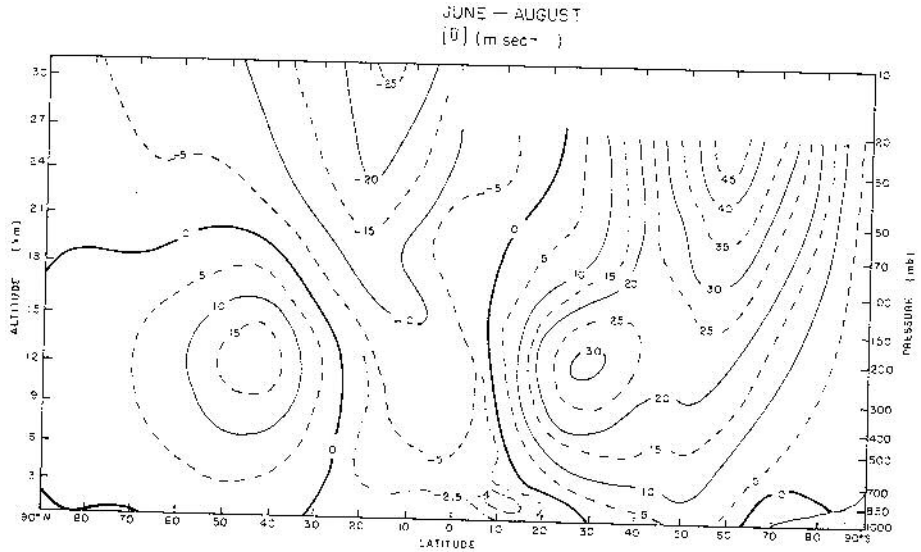
Instantaneous – Jan. 22, 1979



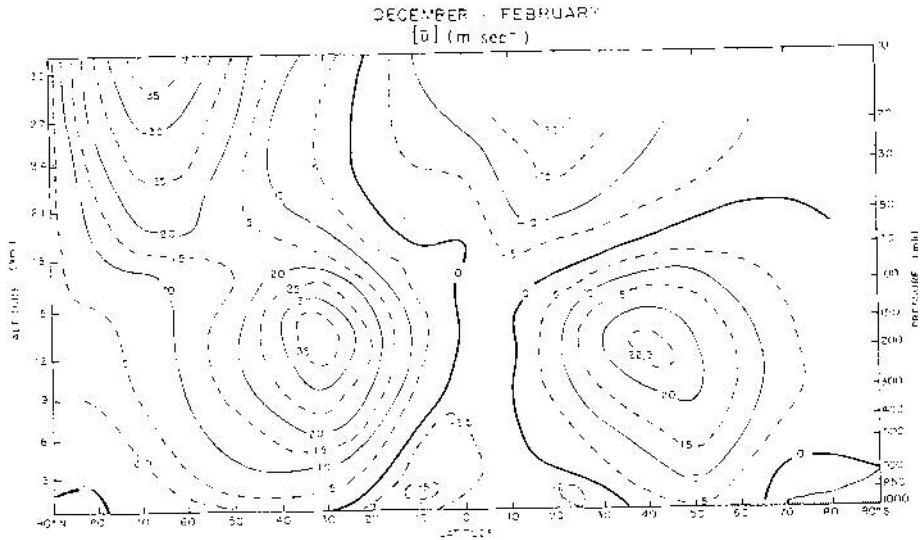
Jan. avg.



TIME and ZONAL average jets located ~ 30° (winter), 45° (summer)



JJA



DJF

(Newell et al., 1972)

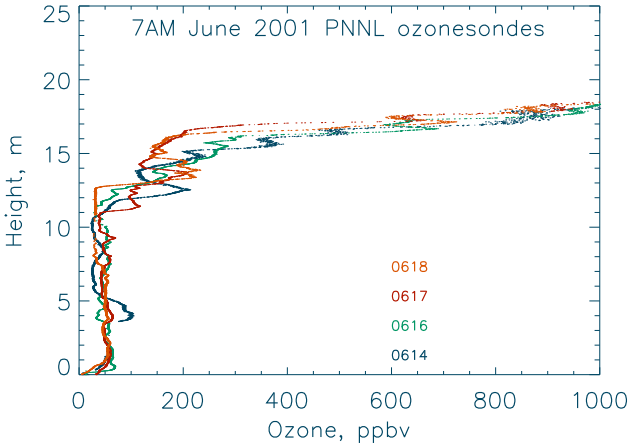
We often examine STE on global, annual basis

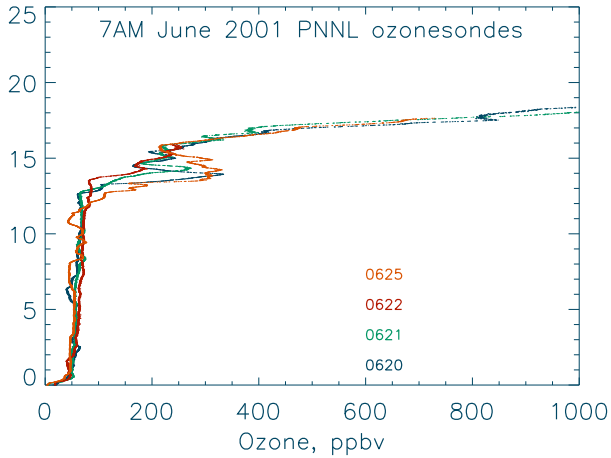
Model	STE, Tg O_3/yr	In-situ P-L	Deposition	Reference
MATCH	1440	-810	620	Crutzen et al. (1999)
MATCH-MPIC	1103	-478	621	Lawrence et al. (1999)
ECHAM/TM3	768	-86	681	Houweling et al. (1998)
ECHAM/TM3[a]	740	-255	533	Houweling et al. (1998)
HARVARD	400	420	820	Wang et al. (1998a)
GCTM	696	128	825	Levy et al. (1997)
UIO	846	295	1178	Berntsen et al. (1996)
ECHAM4	459	75	534	Roelofs and Lelieveld '97
MOZART	391	507	898	Hauglustaine et al.'98
STOCHEM	432	430	862	Stevenson et al. (2000)
KNMI	1429	-855	574	Wauben et al. (1998)
UCI	473	345	812	Wild and Prather (2000)
ECHAM4/CBM4	590	73	668	Roelofs and Lelieveld '00
ECMWF-NMHC	565	140	705	Lelieveld & Dentener '00
GEOS-CHEM	470	600	1070	Bey et al. (2001)
IMPACT– Latitudinally varying tropopause	663	161	826	This work

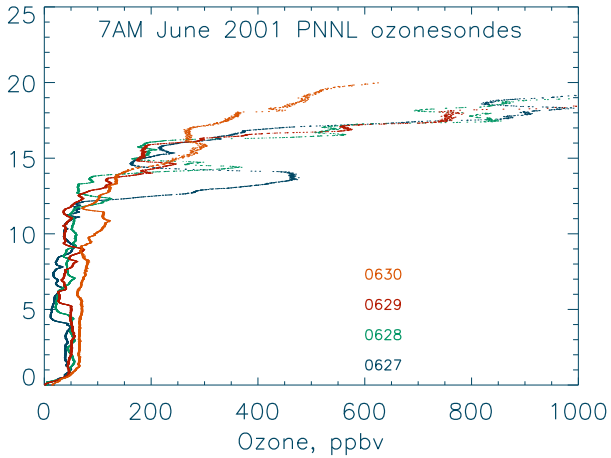
But STE varies regionally, seasonally

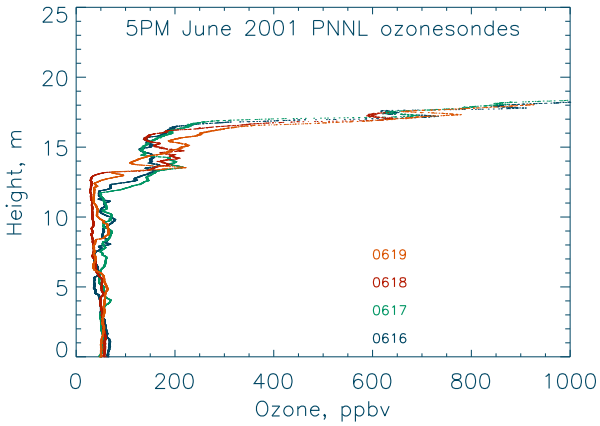
Month	STE, Tg O_3
Jan	58.2
Feb	59.8
Mar	65.4
Apr	61.7
May	62.0
Jun	57.0
Jul	58.7
Aug	51.4
Sep	45.5
Oct	48.9
Nov	42.1
Dec	52.5

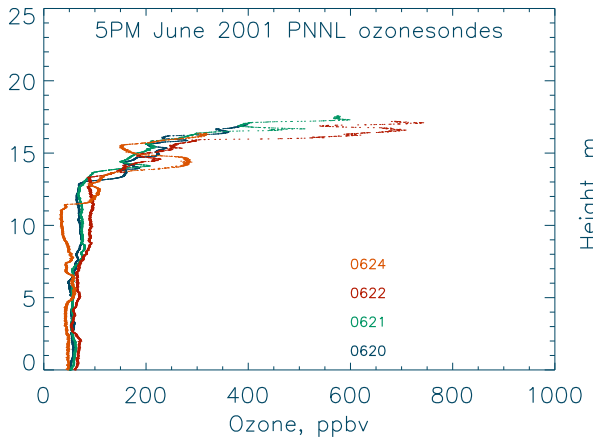
And O_3 vertical structure can vary ~ hours in one location

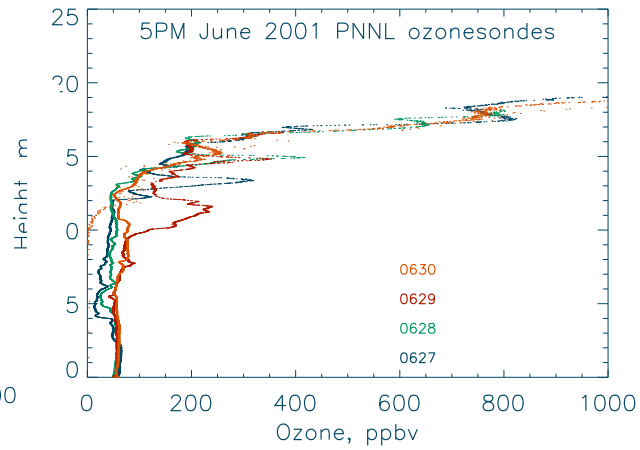










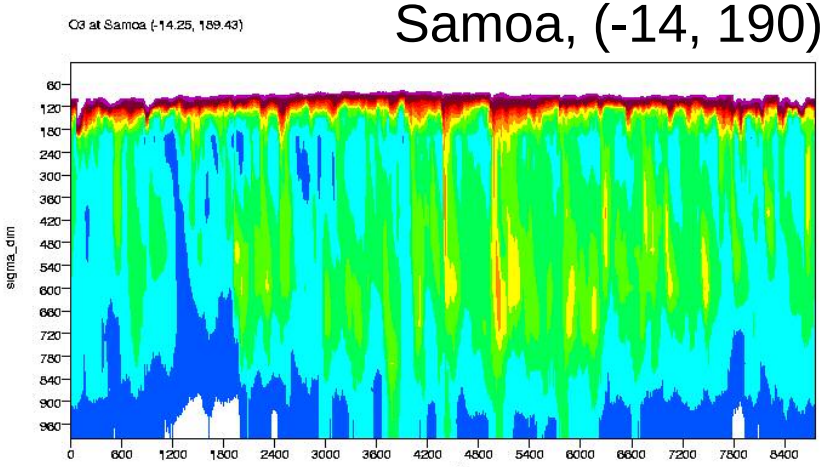


*With thanks to Jerome Fast, PNNL

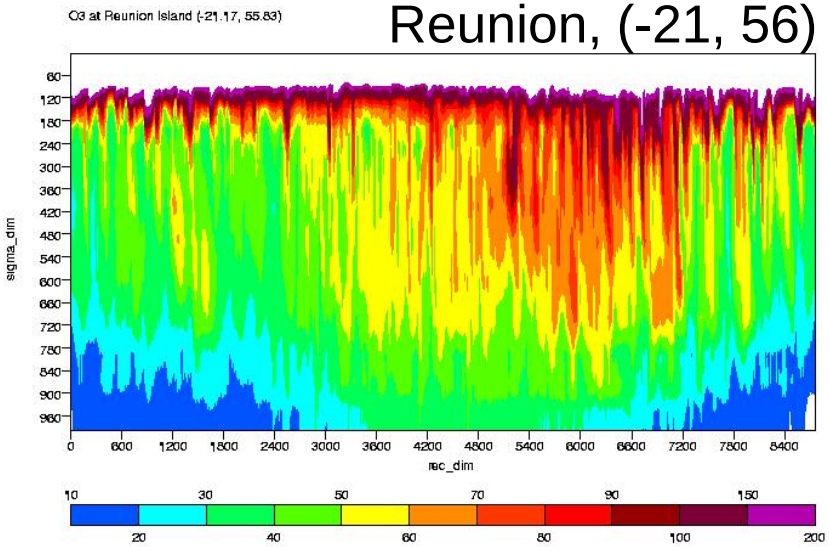
Let’s look at various sites of globe, and then analyze some in more depth……..

Ozone changes as we move away from equator (south)

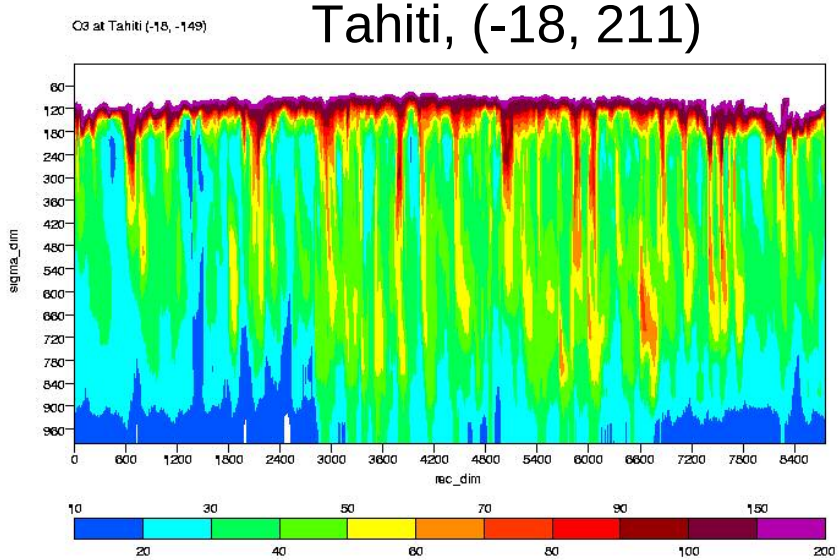
Samoa, (-14, 190)



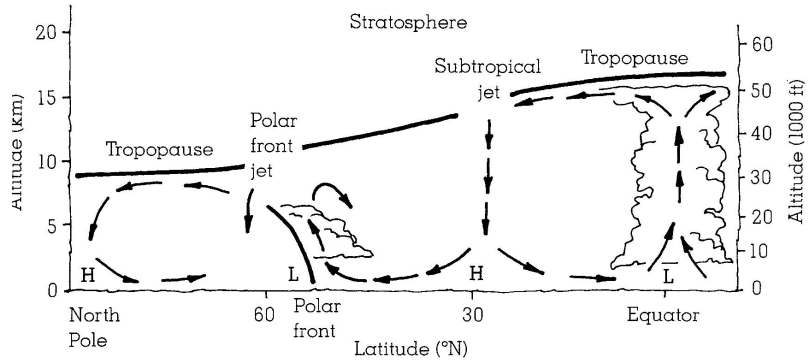
Reunion, (-21, 56)



Tahiti, (-18, 211)

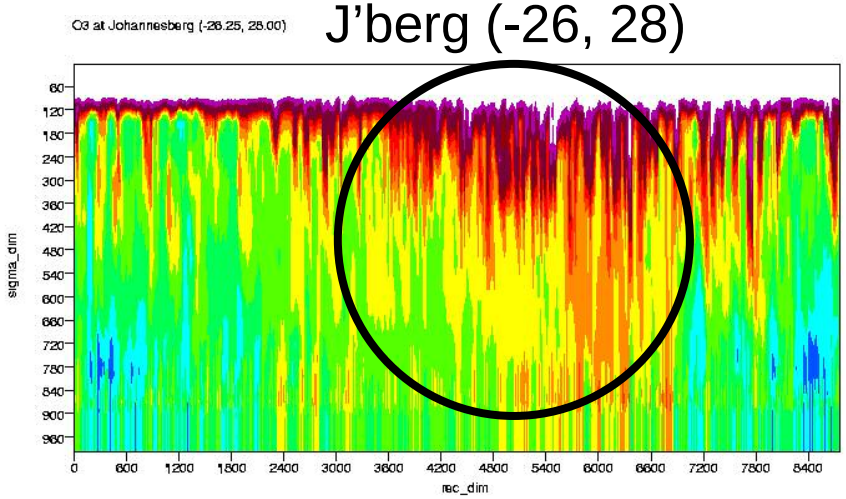


Plots are an entire year's worth of hourly output

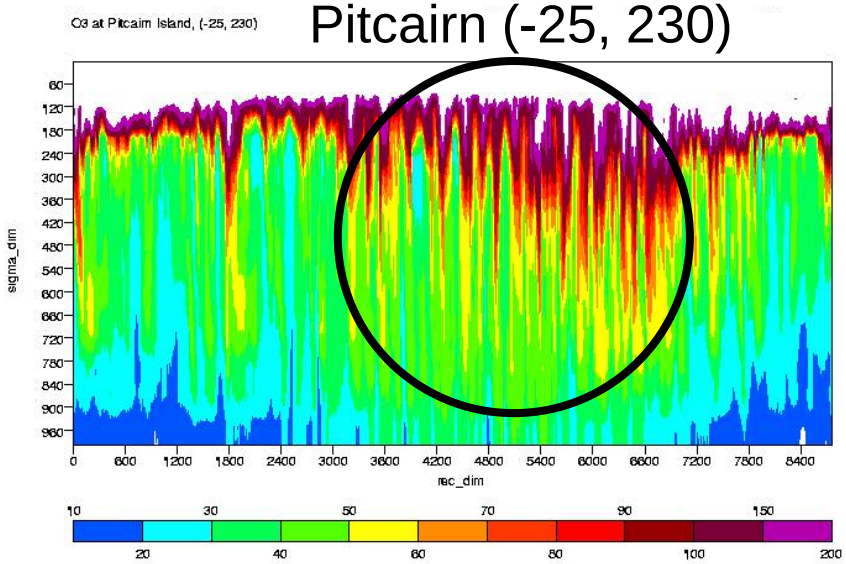


SH sites located near 30°S may show increased transport during winter (midyear in SH)

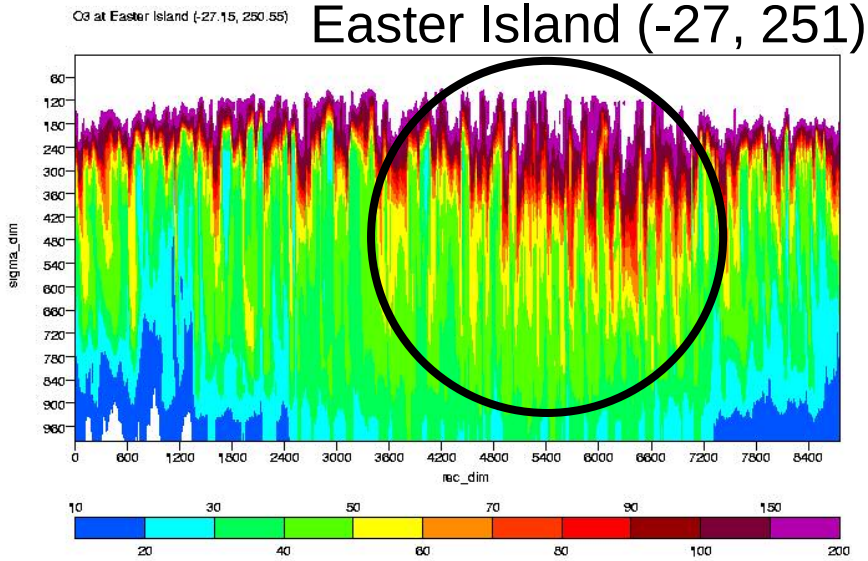
J'berg (-26, 28)



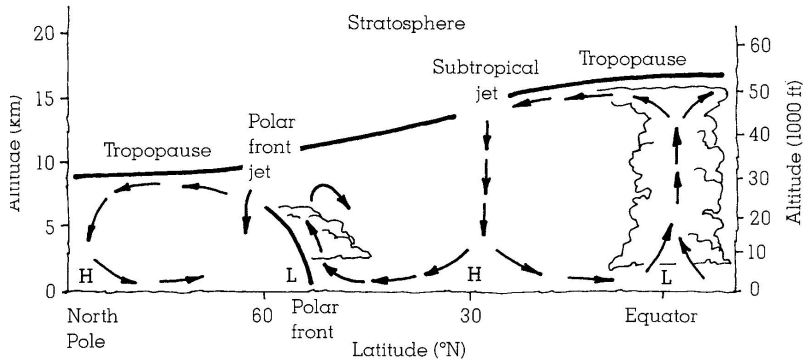
Pitcairn (-25, 230)



Easter Island (-27, 251)

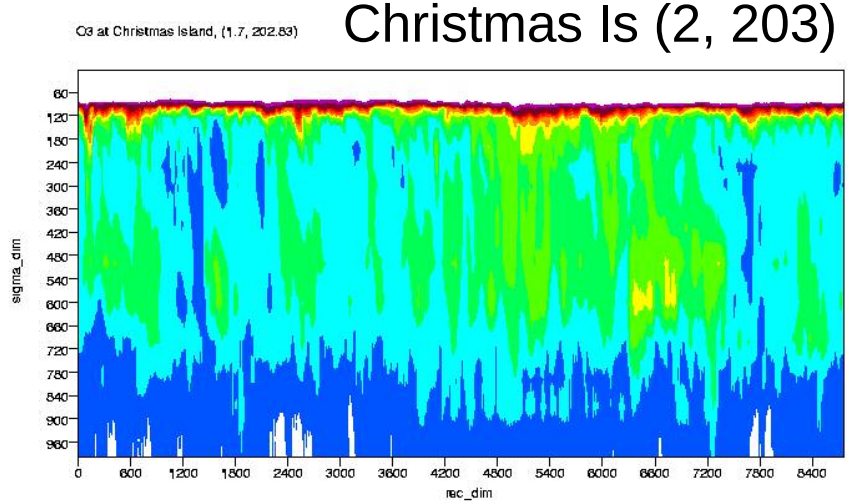


? Winter jet ~ 30°S (midyear) ?

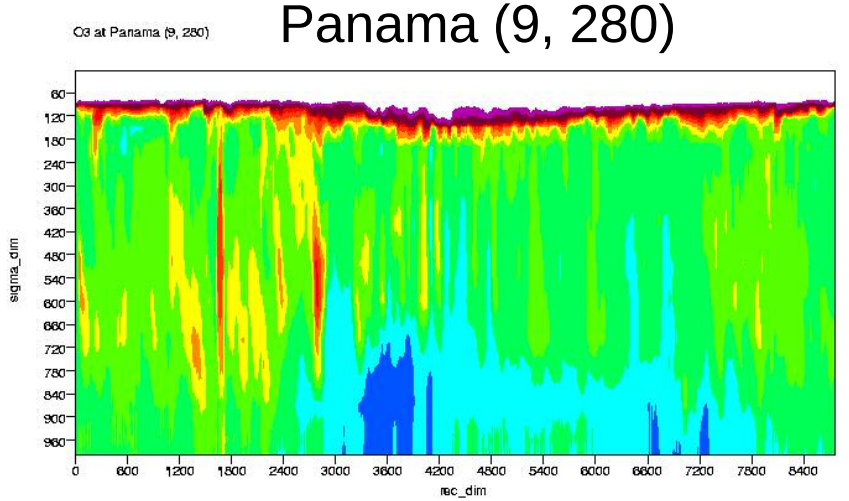


Ozone changes as we move away from equator (north)

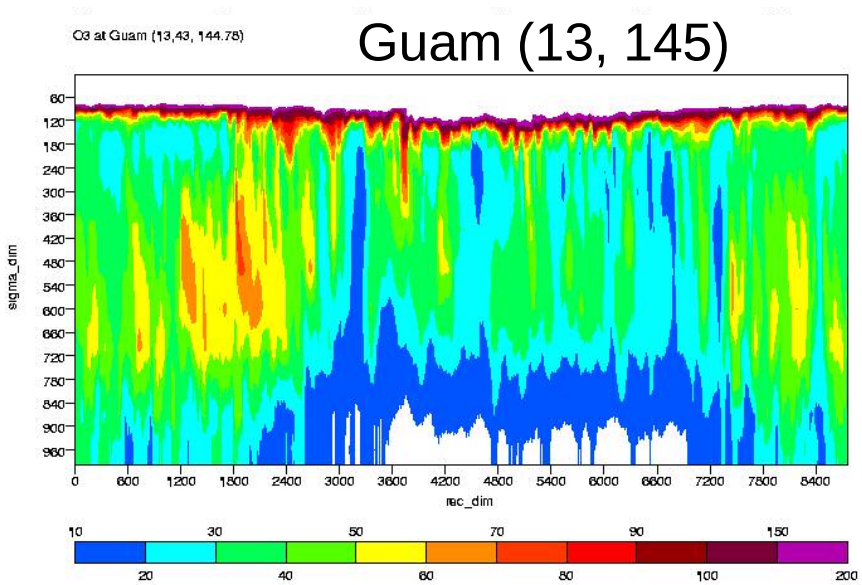
Christmas Is (2, 203)



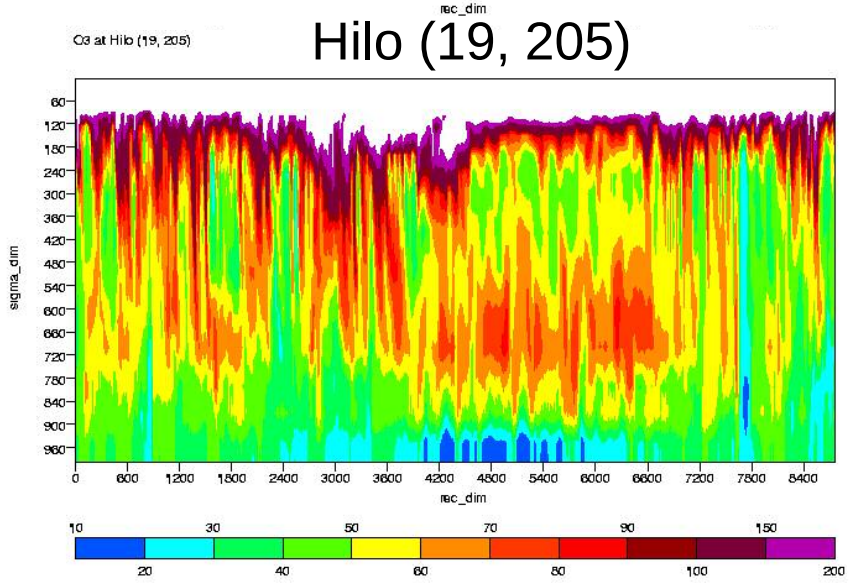
Panama (9, 280)



Guam (13, 145)

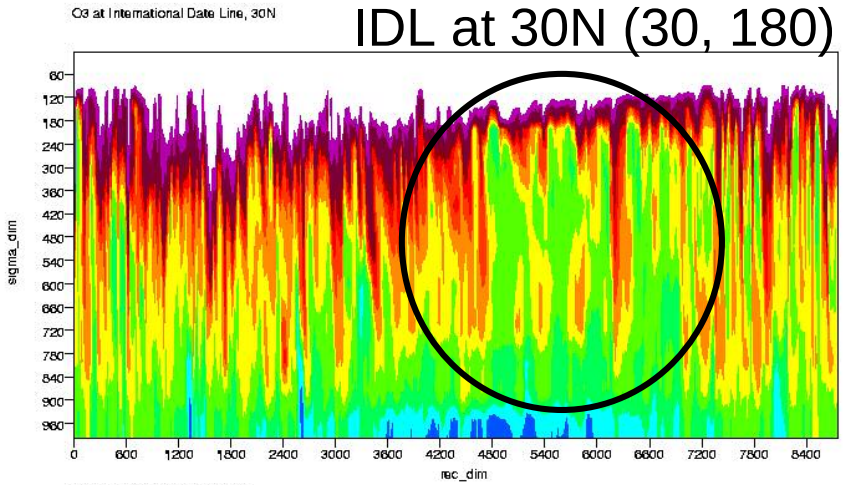


Hilo (19, 205)

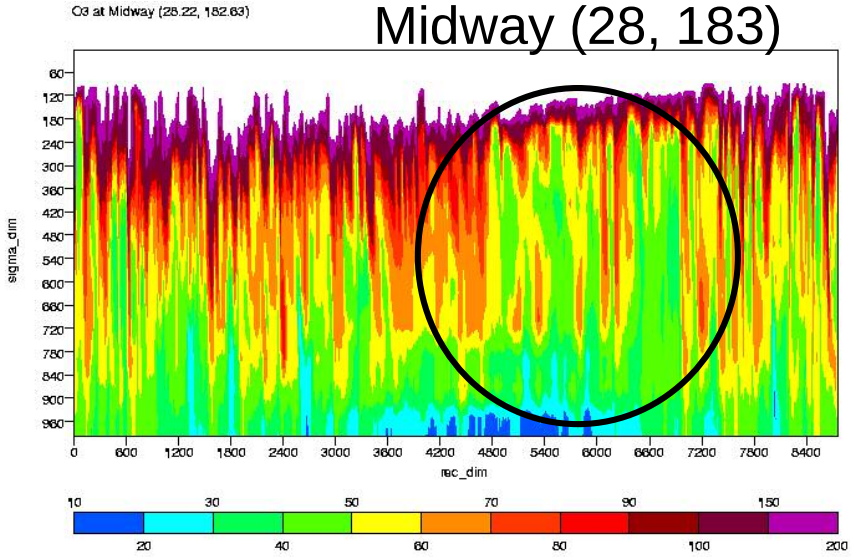


NH sites located near 30°N – Pacific Ocean

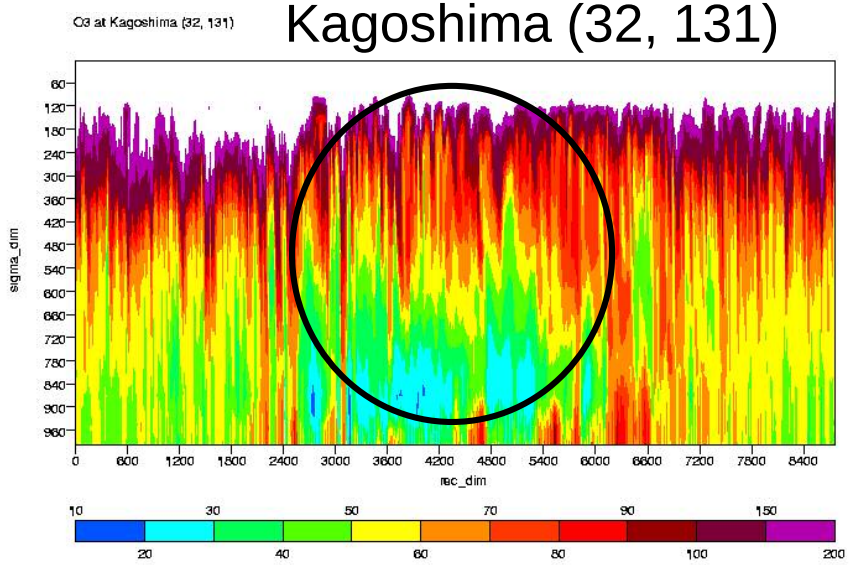
IDL at 30N (30, 180)



Midway (28, 183)



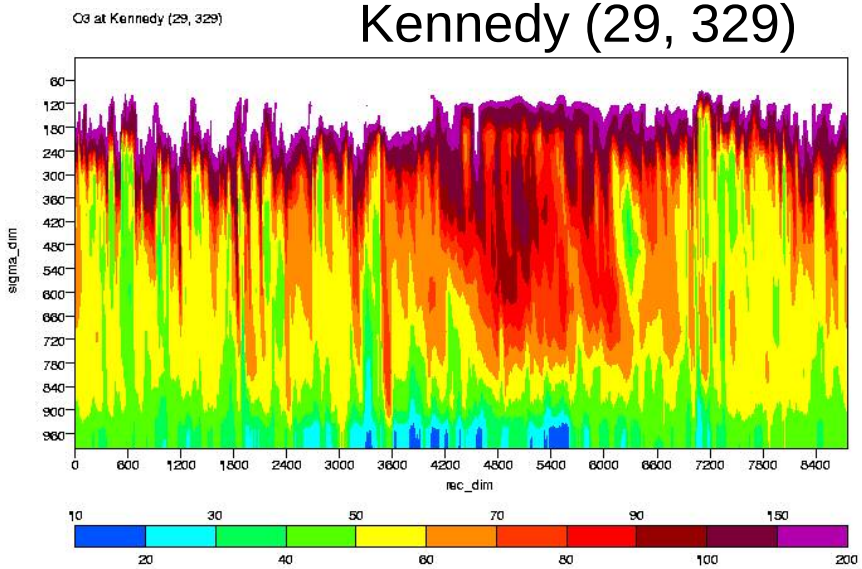
Kagoshima (32, 131)



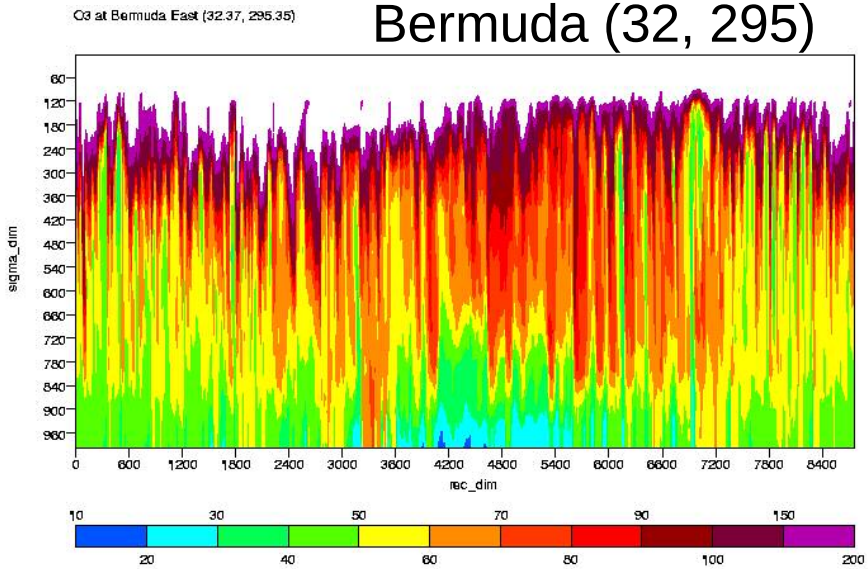
Winter jet ~ 30°N implies more activity in winter; less activity in summer?

NH sites located near 30°N ~ Atlantic Ocean

Kennedy (29, 329)



Bermuda (32, 295)



Getting more complicated…

? Global surface pressure patterns vs flowing jet stream ?

? In-situ photochemistry ? Transport of O3 ? Transport of precursors?

Role of global surface patterns vs jet stream – July?

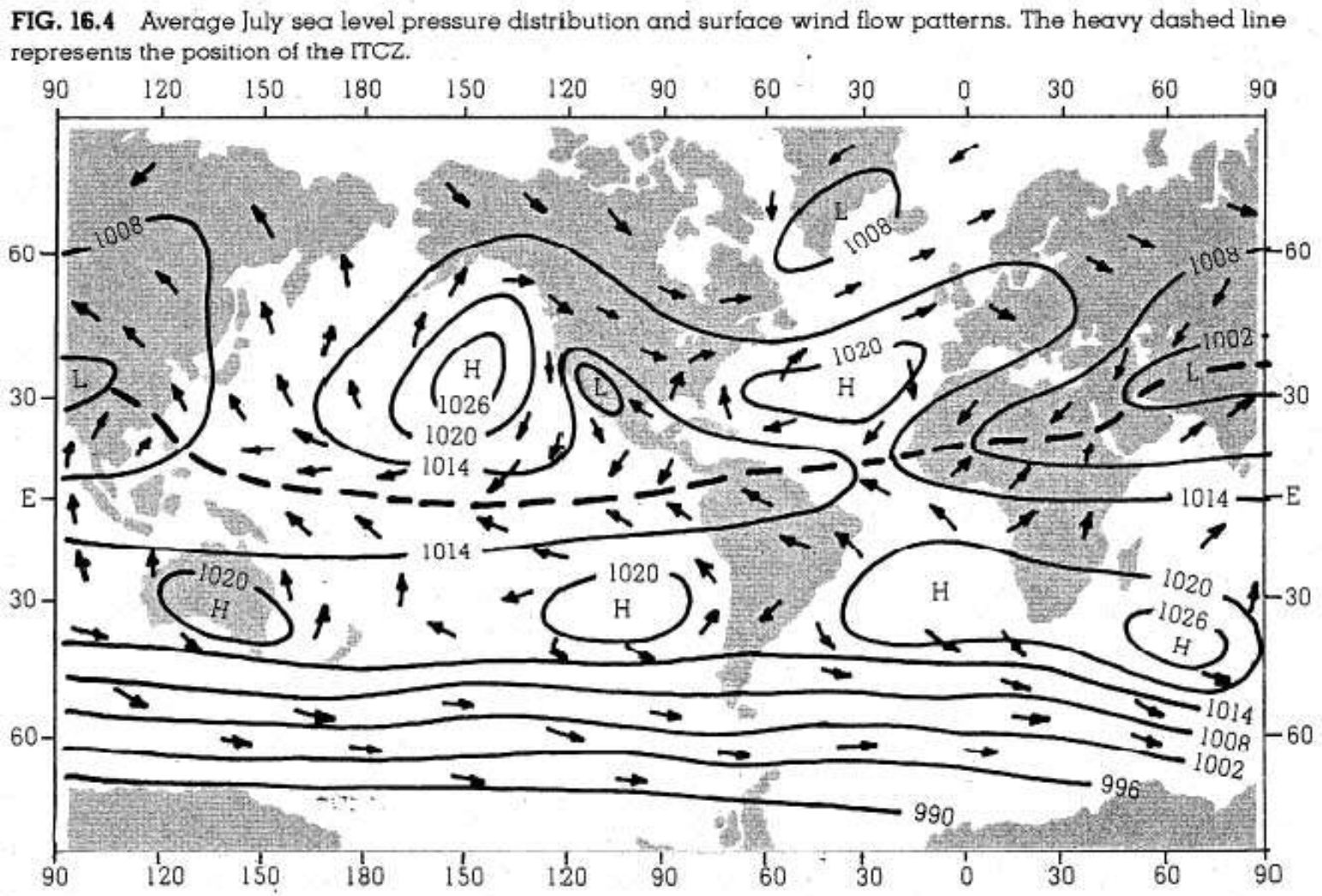


FIG. 16.4 Average July sea level pressure distribution and surface wind flow patterns. The heavy dashed line represents the position of the ITCZ.

Look at budgets, observations for more info…..

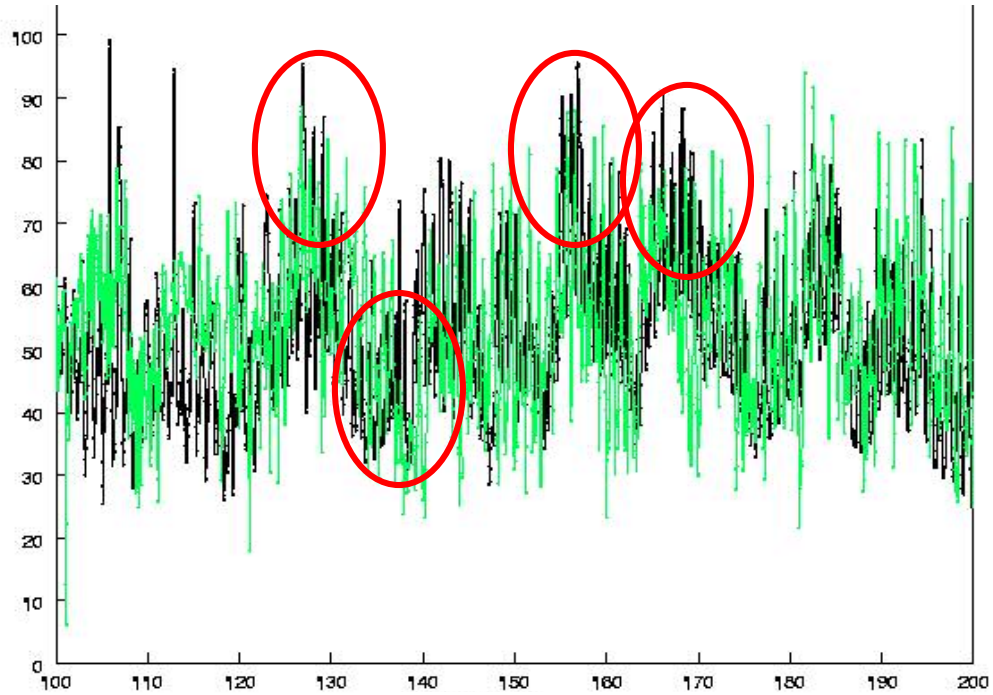
- Phoenix 2001 campaign – June/July

- SHADOZ sondes - 2001

When do observations and IMPACT show extreme O_3 surface concentrations in 2001?

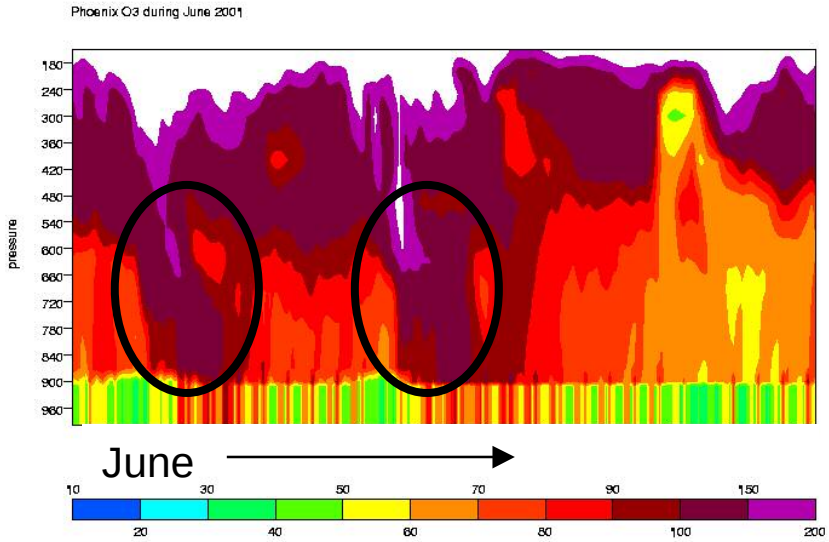
Phoenix observations IMPACT model

O_3, ppbv

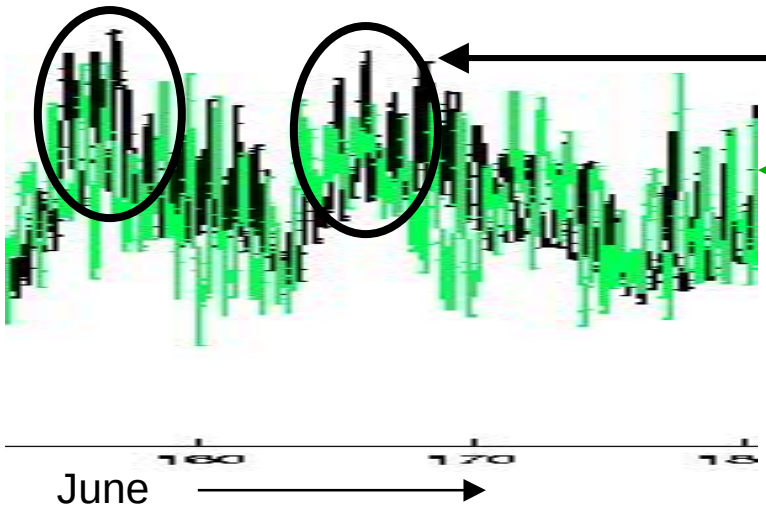


Julian Day in 2001

There are time periods of high surface O_3 coinciding with high overhead O_3 during June 2001 at Phoenix



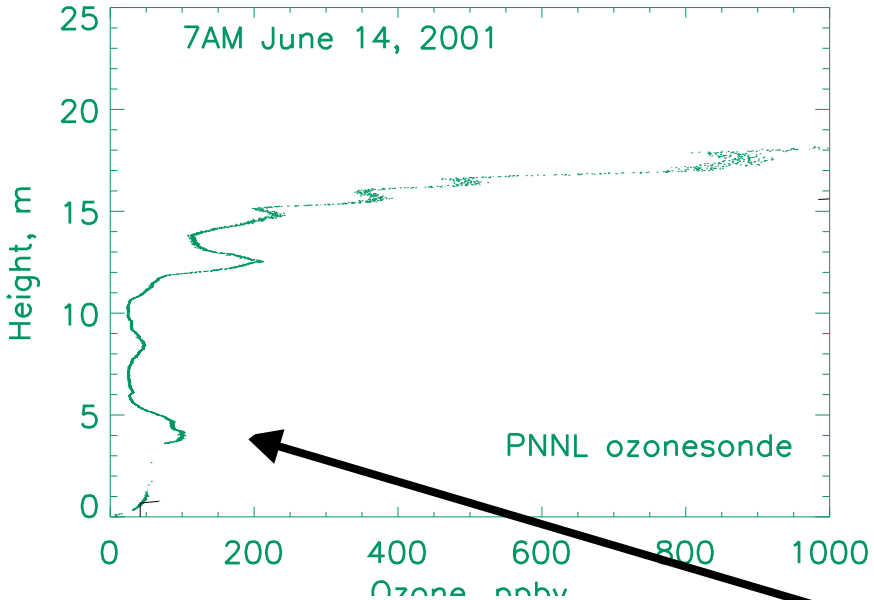
Model vertical O_3 for 6/1-6/30

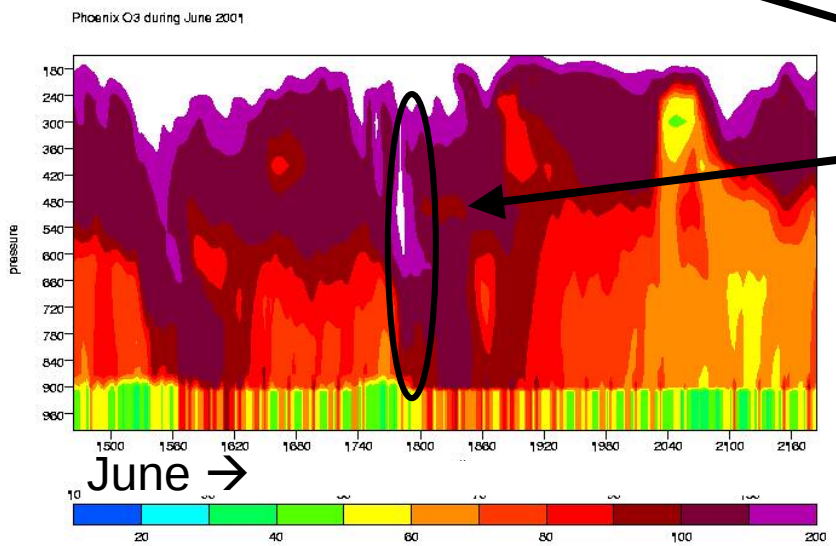


Surface – Model prediction

Surface - Observations

IMPACT results, PNNL ozonesondes, ^{7}Be show similar structure during the peak ~ June 14-15, 2001 @ Phx





June 14, 2001